CLADONIA SUBRANGIFORMIS IN NORTH AMERICA[1]

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Among the *Cladoniae* belonging to the subsection *Chasmariae*, *C. furcata* (Huds.) Schrad., *C. subrangiformis* Sandst., and *C. rangiformis* Hoffm. constitute a group of closely related species. The primary squamules in this group are well developed but short-lived. Many of the specimens, in consequence, are composed entirely of podetia which die at the base and continue growing at the apex until their growth is terminated by the appearance of apothecia or by some other cause. The podetia, which are cupless and terete, branch repeatedly by dichotomies or whorls and form complex branch-systems, comparable with those of the *Unciales*. Both closed and open axils are present in most cases, and podetial squamules may be lacking altogether or more or less abundantly produced. The podetial wall is bounded on the outside by a well-developed cortex and on the inside by a continuous layer of cartilaginous tissue surrounding the central canal. In many cases numerous podetia are associated in extensive colonies.

Of the three species under consideration *C. furcata* is by far the commonest and has an almost cosmopolitan distribution. Vainio (1887, p. 361) assigns a similar distribution to *C. rangiformis* and cites stations for the species from all the continents including Australia. In North America, however, *C. rangiformis* is apparently much rarer than the published records imply, and the writer has seen no specimens that agree fully with authentic European material. The range of *C. subrangiformis* is incompletely known. All three species exhibit a wide range of variation in size, in color, in the extent of the branching, and in the characters derived from the podetial surface. This is particularly true of *C. furcata* under which a number of varieties and forms are now recognized. The forms of *C. subrangiformis* and *C. rangiformis* parallel those of *C. furcata* to a certain extent, and it is difficult in some cases to assign specimens definitely to the species of the group on the basis of morphological characters alone.

In the following account of *C. subrangiformis* a list of the

[1] Contribution from the Osborn Botanical Laboratory.

North American specimens in the Yale Herbarium is given, and the characters which have been assigned to the species are discussed.

CLADONIA SUBRANGIFORMIS Sandst. Abhandl. Naturw. Ver. Bremen **25:** 165. 1922. *Cenomyce furcata* δ. *hamata* Del. in Duby, Bot. Gall. 622. 1830. *Cladonia furcata* var. *palamaea* f. *hamata* Oliv. Expos. Lich. Ouest France **1:** 69. 1897. *C. furcata* var. *palamaea* f. *spectabilis* Zahlbr. Oesterr. Bot. Zeitschr. **57:** 26. 1907. [*C. furcata*] **C. subrangiformis* Des Abbayes, Bull. Soc. Sci. Bretagne **14:** 154. 1937.

On dry soil, preferably calcareous but not uniformly so. Widely distributed in Central Europe and recently reported from Venezuela (Sandstede, 1938, p. 86). New to North America.

MASSACHUSETTS, BARNSTABLE COUNTY: Brewster, *Evans*, 1929; South Chatham, *Torrey*, 1930; Eastham, *Evans*, 1935. MARTHA'S VINEYARD: between Oyster and Job's Neck Ponds, *Torrey*, 1936; east of Oyster Bay, *Torrey*, 1936. NANTUCKET: Gibb's Point, *Torrey*, 1937; Siasconset Road, *Torrey*, 1936; without definite stations, *Sheldon*, 1940; Eel Point region, Great Point, and Sesachacha, *Sheldon*, 1940.

CONNECTICUT, LITCHFIELD COUNTY: Washington, *Evans*, 1922 (listed, Trans. Connecticut Acad. **30:** 423. 1930, as *C. furcata* var. *subclausa*); New Milford, *Evans*, 1928 (listed, Ibid. 420, as *C. furcata*).

NEW YORK, LONG ISLAND: Manorville, *Latham*, 1937; Sag Harbor, *Latham*, 1946; East Hampton, *Latham*, 1947.

MEXICO: without definite station, *E. Palmer*, 1878.

JAMAICA: Cinchona and vicinity, *Johnson*, 1903 (University of Michigan Herbarium); *Seifriz*, 1919; *Maxon* and *Killip*, 1920 (listed, The Bryologist **50:** 42. 1947, as *C. cubana*); below Newhaven Gap, *Maxon* and *Killip*, 1920; between Castleton and Hardware Gap, *Evans*, 1937, 1938.

When Sandstede proposed *C. subrangiformis* as a new species in 1922 he used the phrase "n. spec.," thus implying that he was the author of the name; and in Nos. 784 and 882 of his *Cladoniae* Exsiccatae, distributed in the same year, the labels are inscribed "*Cl. subrangiformis* Sandst." In Nos. 1159 and 1182, however, distributed in 1923, and in No. 1842, distributed in 1929, the labels are inscribed "*Cl. subrangiformis* Scriba." In 1931 (p. 231) Sandstede gave, as the reason for this change, the fact that Scriba was the first to recognize the species. In the opinion of the writer this reason is inadequate, and Sandstede's name should be restored as the author of the species.

In his original description of *C. subrangiformis* Sandstede emphasized the presence of conspicuous white spots on the older parts of the podetial surface, and such spots are clearly shown in the figure published by Anders in 1928 (pl. 9, fig. 11) and in the

later figure published by Sandstede himself in 1931 (pl. 15, fig. 6). They represent masses of interwoven hyphae derived from the outer medullary layer of the podetial wall. Through the action of some stimulus the hyphal cells in localized areas are incited to grow and divide, and the masses of such hyphae as they increase in size rupture the cortex and thus become exposed to the air. The algal cells among the hyphae soon lose their green contents and are distinguished only with difficulty.

According to Bachmann's observations, which Sandstede cites in detail, the spots contain no soredia, and their development is not caused by the presence of a parasitic fungus. It is suggested that they may represent a response to unfavorable climatic conditions, such as those associated with very dry habitats. It is pointed out also that similar white spots may develop in *C. rangiformis* var. *muricata* (Del.) Arn., when growing with *C. subrangiformis*, and Asahina has since detected such spots in *C. furcata* (1942, p. 669). In all probability the spots are pathological in character, as Anders intimates (1928, p. 76), since their development is restricted to special habitats; and Asahina states definitely that they are abnormal and that they are associated with the deposition of calcium oxalate in the outer medulla. In any case little or no taxonomic significance can be assigned to the spots, in spite of their conspicuous appearance, and other characters will have to be used in distinguishing *C. subrangiformis* from its allies.

Among the other features of the species to which Sandstede called attention in his original description are the bitter taste, the definite and persistent yellow color induced by treatment with K,[2] and the following morphological characteristics of the podetia: the robustness, the presence of numerous lateral outgrowths, the sharp apices of the sterile ultimate branchlets, the scanty development of podetial squamules, and the wrinkled and rimose surface of the basal portion. In *C. furcata*, which is likewise bitter to the taste, treatment with K produces a dull yellow color which quickly deepens to a dingy reddish brown. Of course the K+ yellow reaction indicates the presence of atronorine and the bitter taste the presence of fumarproto-

[2] The letter "K" is an abbreviation for an aqueous solution of potassium hydroxide, and the letter "P" for an alcoholic solution of paraphenylene-diamine.

cetraric acid. The P+ red reaction now supplements the bitter taste in the demonstration of the latter substance.

In 1937 Des Abbayes discussed the characters of *C. subrangiformis* and emphasized its relationship, not only to *C. furcata*, but also to *C. rangiformis*. Typical specimens of *C. subrangiformis*, according to his conception, are definitely P+ yellow and have robust podetia with white spots in the basal portion. The podetia develop also a variable number of lateral outgrowths in the form of spines and are colored more or less brown by exposure to the sun.

Between such specimens and specimens of *C. furcata* he distinguished a number of intergrading forms from France, based partly on morphological features and partly on chemical. These intergrading forms include specimens with the following types of podetia: slender podetia without white spots, which agree morphologically with *C. furcata* var. *palamaea* (Ach.) Vainio f. *implexa* (Floerke) Aigret but which are K+ yellow; slender podetia with white spots, which agree morphologically with *C. furcata* var. *palamaea* f. *spadicea* (Pers.) Aigret but which are likewise K+ yellow; robust podetia without white spots, which agree morphologically with *C. furcata* var. *palamaea* f. *recurva* (Floerke) Des Abbayes but which (as in the preceding cases) are K+ yellow; and podetia, which agree morphologically with *C. subrangiformis* but which are not definitely K+ yellow, showing instead the color-changes induced in *C. furcata* by this reagent or some color-change intermediate between these two extremes. Assuming the presence of both fumarprotocetraric acid and atronorine in *C. furcata*, as well as in *C. subrangiformis*, Des Abbayes attributed the different color-reactions induced by K to differences in the relative amounts of these two lichen-substances in the specimens tested.

From the data which have just been summarized Des Abbayes concluded that *C. subrangiformis* did not constitute a distinct species but that it represented a well-marked variety of *C. furcata*. At the same time he assigned to it an ecological significance, since he associated it with a special habitat, and on this basis maintained the name *C. subrangiformis*, preceding it with an asterisk to indicate its subordinate character.

Des Abbayes distinguished also intergrading forms connecting

C. subrangiformis with *C. rangiformis*. The latter species is definitely K+ yellow, indicating the presence of atronorine, and most specimens are P−, indicating the absence of fumarprotocetraric acid. Occasional specimens are met with, however, which are P+, although this reaction may be restricted to the podetial squamules; and specimens of this sort, in which traces at least of fumarprotocetraric acid are present, were interpreted by Des Abbayes as intergrades.

In 1942 Asahina published the results of his microchemical studies on various *Chasmariae*, including *C. furcata*, *C. subrangiformis*, and *C. rangiformis*. His studies of these three species were based on European material distributed by Sandstede in his *Cladoniae* Exsiccatae, supplemented in the case of *C. furcata* by Japanese and North American material. This material included 62 specimens from Europe, an indefinite number from Japan, and 46 from North America, and he found that atronorine was lacking in all, with the exception of four from Europe and one from North America. Although Zopf in 1908 had reported the presence of atronorine in *C. furcata*, Asahina concluded from his results that fumarprotocetraric acid was the only lichensubstance characteristic of the species and that the material examined by Zopf must have been mixed. He concluded further that specimens containing atronorine, which had been referred to *C. furcata*, must either be excluded from the species altogether or interpreted as transitional forms between *C. furcata* and *C. subrangiformis*.

His material of *C. subrangiformis* consisted of the five specimens in Sandstede's Exsiccatae. He demonstrated both atronorine and fumarprotocetraric acid in four of these but found the latter substance only in No. 1182. He therefore suggested that this specimen, in spite of its conspicuous white spots, might be interpreted as a form of *C. furcata* paralleling *C. subrangiformis*.

In the case of *C. rangiformis* Asahina found that 25 of Sandstede's numbers were P− but that 4 were P+, thus confirming the statements made by Des Abbayes. He found further that all these specimens, whether P− or P+, contained both atronorine and rangiformic acid, although the amount of the latter substance might be too small to be demonstrated readily by microchemical methods.

The writer, as late as 1950 (p. 92), expressed the opinion that atronorine represented a rare accessory component of *C. furcata* and called attention to a number of specimens so-named from southern New England in which this substance had been demonstrated. If, however, Asahina's conclusions are accepted, these specimens should no longer be retained under *C. furcata*, and it seems justifiable to transfer them directly to *C. subrangiformis*, under which they are listed in the present report. The same course should probably be pursued with the K+ yellow specimens which Des Abbayes interpreted as intergrades between *C. furcata* and *C. subrangiformis* and with some at least of his specimens in which the K+ yellow reaction was obscured by the large amount of fumarprotocetraric acid present. Des Abbayes himself, in fact, distributed one of his K+ yellow intergrades, represented by No. 48 of his Lichenes Gallici, under the name *C. subrangiformis*. The "intergrades" between *C. rangiformis* and *C. subrangiformis*, which Des Abbayes distinguished, have not been reported from North America and are hardly to be expected, since the occurrence of *C. rangiformis* itself on this side of the Atlantic is somewhat problematical.

The recognition of atronorine as a characteristic lichen-substance of *C. subrangiformis*, but not of *C. furcata*, makes it practicable to separate the species from each other without difficulty, since atronorine is readily demonstrated by means of Asahina's G.A.o-T. solution. It must be admitted, however, that the known forms of *C. subrangiformis* parallel forms of *C. furcata*. The K+ yellow intergrades of Des Abbayes, for example, have the morphological features of *C. furcata* var. *palamaea*, and some of the specimens from Massachusetts have the morphological features of *C. furcata* var. *racemosa* (Hoffm.) Floerke. As a matter of fact no constant morphological distinctions between the two species have as yet been pointed out. The relation of *C. subrangiformis* to *C. furcata*, therefore, is similar to that of *C. ecmocyna* (Ach.) Nyl. to *C. gracilis* (L.) Willd. (see Evans, 1952).

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The Occurrence of Rubus Chamaemorus in Minnesota.—From the Quetico-Superior Wilderness area is herewith recorded the addition of *Rubus Chamaemorus* L. to the flora of Minnesota. Its discovery was not surprising to the veteran botanists of the state. It came as a fulfillment of expectations consistent with previously known boreal elements in the flora of the area.

The plant was discovered by Mr. Clifford Ahlgren, Research Director of the Quetico-Superior Wilderness Research Center at Basswood Lake. His collection came to my attention, July 10th, last, while identifying and checking herbarium materials at the Research Center Herbarium. His collection, No. 3000 was made on June 13, 1954 from a bog forest along the Back Bay of Basswood Lake, when the plants were in full flower. On July 30, I was privileged to accompany Mr. and Mrs. Ahlgren on their return to the bog for additional collections.

The particular area of the bog including the *Rubus* colony is in sect. 17, Twp. 64, R. 10 at 48° 7′ N. lat. and 92° 43′ W. long. in Lake County. The swampy shoreline about one mile in extent with a dense growth of alder and dwarf birch passes abruptly into a sphagnum bog with a mature black spruce forest. The forest, about one-fourth mile wide and flanked by a high ridge, is moderately dense and moist, with a deep sphagnum ground-cover and